NITROGEN USE AND EFFICIENCY IN EASTASIAN AGRICULTURE -TO A STEP FOR APPLICATION TO AFRICA-

Shin-ichiro Mishima

National Insitute for AgroEnviromental Sciences
Kannondai 3-1-3 Tsukuba Ibaraki 305-8604 Japan

.....

Shin-ichiro Mishima holds a Doctor degree in Integrated Arts and Sciences from Hiroshima University (Japan) and is a Senior Researcher of National Institute for Agro-Environmental Scicences, Japan. He works about nitrogen, phosphorus and potassium use and production on agro-ecosystem in Japan.

ABSTRACT

To determine the available nitrogen (N) resource budgets and balance (application minus plant uptake), we obtained data on inorganic fertilizers and livestock manure from statistical yearbooks for Japan, the Republic of Korea (hereafter, Korea), and China. Uptake of N via crop production was also calculated using national nutrient content factors. From the N budget and crop production data, we calculated the N balance and use efficiencies. Japan used too much N, Korea balanced its use of inorganic fertilizer but needed to improve when combined with manure use, and China had high nutrient inputs and outputs in crop yield. To improve nutrient use efficiency and decrease the surplus, we defined a manure budget based on nationally available N sources, with the goal of using manure first, followed by inorganic fertilizer. Based on this analysis, Japan should apply inorganic N fertilizer primarily then use livestock waste N to compensate for a soil N, Korea should develop forage crop production and build recycling pathways within the country, and China should reduce its excessive use of N.

Management of N appears to be acceptable and efficient. Japanese and Chinese N resource budgets and outputs in crop production appear reasonable, but the high N surplus should be decreased through more efficient use of inorganic N fertilizers. The present results suggest that increasing soil fertility and improving the use of livestock manure will be the key for sustainability in all three countries.

These countries has too enough nutrient budget and soil fertility data sets, therefore, they could manage and control N use. However there would be difficulty to adopte for African countries. I will touch to future needs for information of nutrient budget approach for enhancing African agriculture.

KEYWORDS

Balance, Budget, National Scales, Nitrogen

NITROGEN USE AND EFFICIENCY IN EAST ASIA AGRICULTURE

-to a step for application to Africa-

S. Mishima Ph.D

National Institute for Agro-Environmental Sciences

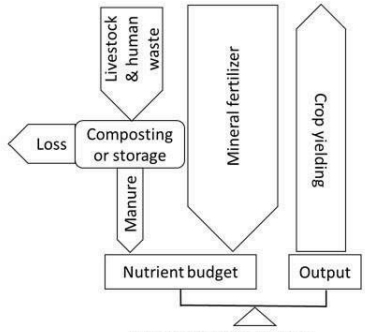
1

Introduction

- Nutrient use and balance
  - Indicator for sustainability
  - Surplus
    - N, P load to environment
    - Unbalance of K in soil
  - Deficiency
    - Reduce soil fertility

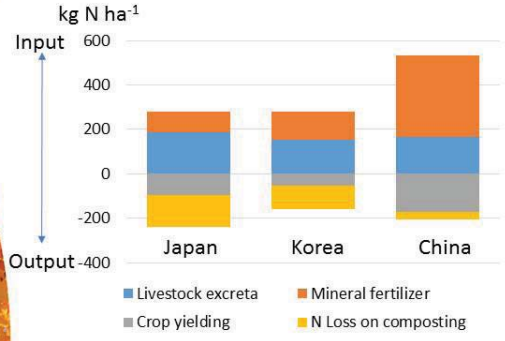
2

Framework



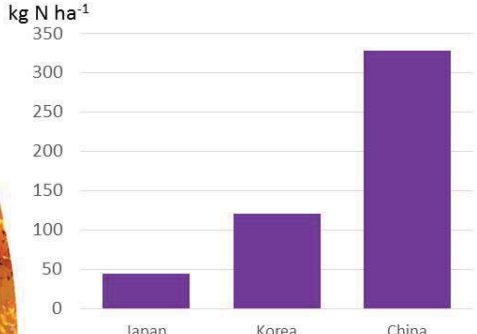
3

N balance at East Asia in 2010



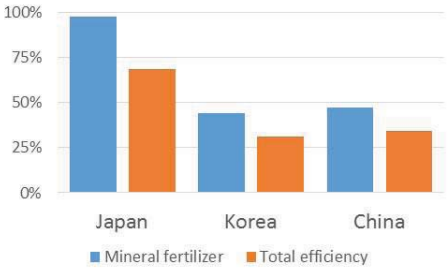
4

N balance



5

N use efficiency



6

Evaluation

- High efficiency in Japan
  - Large loss during composting
  - Low input of N
- Low efficiency in Korea & China
  - High N input
    - 50% efficiency might be enough
    - Additional manure N made low efficiency
  - Low loss on composting in China
    - Immature manure

7

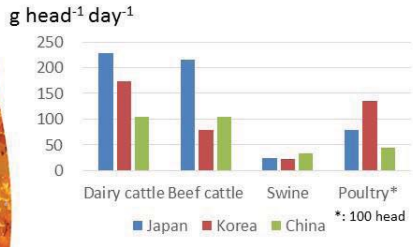
Data for calculation

- Local agricultural statistics
  - Yield, head number etc.
- Food and feed nutrient composition table in 3 countries
- Livestock excretion per head in each country
- Manure composition table in each country

8

Importance of factors

- N content in food
- N excretion by livestock



9

Application to Africa

- National statistics and factors
  - Can we leave from FAO stat?
  - N, P, K content in crop etc.
- Style of agriculture
  - Livestock grazing or in shed
- Suitable model
  - Framework, boundary

10

From past studies

- Nutrient deficiency, depletion
- Mineral fertilizer is difficult to afford
- Importing a lot of food
  - Structural problem?

11

Sustainable Intensification

- Where can we get fertilizer?
- Nutrient budget in…
  - human and livestock waste
    - Need quantitative assessment include affordability
  - Crop residue management
    - As source of humus (soil C)
  - Garbage, swage in urban area

12

An example: Uganda

Cassava	1.71		
Potato	0.81	Human*	18.65
Maze	4.85	Cattle*	31.92
Sum	7.37	Fertilizer	0.94

N Production N budget kgN ha^{-1}

*: estimated with Chinese factor

- Mineral fertilizer is too small
- Amount of human and cattle waste is enough large

13

Evaluation

- Human and livestock waste would be hopeful resource
- Need more assessments
  - Affordability of Livestock waste…grazing?
  - Can use human waste?
    - Sanitation, etc.
  - Loss of N during processing
    - Storage, composting

14

Conclusions

- 3 countries in East Asia have their own situations, ideas and styles
  - But same rice oriented agriculture
- Adopt to African countries
  - Availability of fertilizer resource
  - Suitable model, native data

15

Acknowledgements

- Survey in China was funded by JIRCAS
- Survey in Korea was funded by "Resource Logistics", a JST RISTEX project

16

Thank you !

shin@affrc.go.jp

17

Chair Tobita: Next I'd like to introduce second speaker Dr. Shin-ichiro Mishima. He has a doctor degree in the Integrated Arts and Sciences from Hiroshima University and now he is a Senior Researcher of the National Institute for Agro-Environmental Sciences, Japan. Now, he works about nitrogen, phosphorus and potassium use and production on agro-ecosystem in Japan. His presentation title is "Nitrogen Use and Efficiency in East Asian Agriculture-To A Step for Application to Africa-" Okay, Dr. Mishima-san, please.

Dr. Shin-ichiro Mishima: Thank you, Chairman. I will speak about Nitrogen Use and Efficiency in East Asia and I will show you one example in Africa.

At first, nutrient use and nutrient balance is a very easy indicator for sustainability, such as surplus of nitrogen, phosphorus will cause load to environment, such as eutrophication of watershed, water, and then greenhouse gas, such as nitrous oxide and too much nitrous oxide emission; and on potassium, it cause unbalance in potassium in soil and deficiency will cause reduce of soil fertility.

Here is the framework about very easy framework for calculated nutrient balance. As left, livestock and human waste is one of the sources of nitrogen in national scale or regional scale, it will be composted or storage then can be used as manure. And mineral fertilizer is one of the very important nutrient sources for agriculture and the output is crop yielding. And nutrient budget divided by output crop yielding is nutrient use efficiency.

Here is result of nitrogen balance in East Asian countries in 2010. Japan, Korea has about almost same amount of livestock excreta nitrogen plus mineral fertilizer and on per crop land area basis, China has a very large input of mineral fertilizer nitrogen. Output is largest in China because of its very high nitrogen content in food and fiber crop and so on. The next is Japan then Korea and yellow part is nitrogen loss during composting. That is very large in Japan, but small in China because Chinese manure is basically not so matured, not well composted so nitrogen loss is very small.

Nitrogen balance in Japan, Korea, China, is here. China has a very large nitrogen surplus.

Nitrogen use efficiency is here and if limited to the mineral fertilizer, the efficiency is very high in Japan and same rate in Korea and China. But mineral fertilizer efficiency for crop about half of nitrogen in crop body comes from mineral fertilizer and the other 50% will come from soil fertility nitrogen that is widely said in Japan. So, this efficiency is not so bad in two countries, but if combined with manure the ratio is much lower. Because especially in Korea they will plan the nitrogen application based on mineral fertilizer application, but they may not consider about manure use so efficiency become low.

On evaluation, high efficiency in Japan is large nitrogen loss during composting and low input of nitrogen. And low efficiency in Korea and China come from high input of mineral fertilizer in China and loss of nitrogen on composting in China.

For calculate these values, I used the local agricultural statistics, such as yield of crop, head number, farmland area and so on; and food and feed nutrient composition table, livestock excretion per head in each country and manure composition table in each country.

Especially main important factors to calculate this nitrogen value is content in food and nitrogen excretion by livestock. Here is an example of nitrogen excretion by livestock. Basically Japanese cattle breeding needs a lot of concentrated feed. So as a result of high nitrogen input to cattle will cause these large excrete of nitrogen excretion from cattle.

If applied this idea or this work to Africa, we will need national statistics and factors. So FAO bring as much about data about national statistics, but I prefer local statistics in each country, as nitrogen, phosphorus, potassium content in crop, and so on will be important because nitrogen content in food has a very wide range if compared with many, many countries. And when we think about the style of agriculture about livestock, it is growing grazing or in shed has a very large difference. And we have to think about suitable model for local country farming system, its framework and setting a system boundary about nutrient balance will be important.

There're many past studies about nutrient use and balance in Africa. For example, nutrient deficiency and depletion of soil fertility and mineral fertilizer is difficult to afford and importing a lot of food from outside of Africa.

If we or Africa have to increase food supply, we will need sustainable intensification, but there're many problems. Where can we get fertilizer? And nutrient budget in fertilizer, one of the aims to nutrient budget will be human and livestock waste and crop residue management. Thinking about surrounding of urban area, garbage and swage, it will be an important source.

I calculated an example about Uganda. There is I picked up three crops, but the production in nitrogen productivity is 7.37 kilograms per hectare. But fertilizer demand or application is just 0.94 kilograms per hectare, so mineral fertilizer is very small. But calculate about the human and cattle waste, nitrogen budget indeed is very large. I was very surprised. Maybe I use Chinese factors to calculate this, so this value is somewhat different from Japan and Korea or other countries. I use Chinese factor because cattle waste production is small, but nutrition condition in cattle will be different from Uganda. So, this is variable and human also will be variable if thinking about local factors.

On evaluation, human and livestock waste may be a hopeful resource, but we need more assessments about affordability of livestock waste. If it is grazing, it will not be affordable. Can we use human waste? It means sanitation or public health problem and we think about the loss of nitrogen during processing, storage or composting and so on.

In conclusion, three countries in East Asia have their own situations, ideas and farming styles, but it has the same basement, namely rice-oriented agriculture. But in Africa, it will be different. We think about availability of fertilizer resource and suitable model and need native data about Africa.

And acknowledgements and that's all.

Thank you very much.

Chair Matsumoto: Thank you very much, Dr. Mishima. He showed us the framework of nutrient budget at the national level, not the farmland level. It's at national level, then for evaluation of the efficiency of nutrient use and the regional resources. Now we have not enough time and we have a few minutes. Do you have any questions or comments? Yes, Dr. Okada?

Dr. Kensuke Okada: Yes. I am very much interested in your presentation and particularly this figure. Can you explain a little bit more and how did you calculate particularly this input from human and cattle sources?

Dr. Shin-ichiro Mishima: Yes, thank you. About human population is just listed in FAO statistics under head number of human population is set as rural area population, not include urban population. That is divided in FAOSTAT. And head number of cattle is also come from FAO statistics. I use Chinese factors for how much nitrogen is excreted per capita or per head of cattle then multiplied this data and I got it.

Dr. Kensuke Okada: Thank you very much. Now, it's very clear. Then, I have to add that in Uganda generally the original soil fertility is relatively high compared to other parts in Africa. So, I think the original soil supply capacity also should be taken into account. I thank you very much for your nice presentation.

Dr. Shin-ichiro Mishima: Thank you very much.

Chair Matsumoto: Thank you very much. Time is up. Then thank you, Dr. Mishima, for your presentation.